Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. Sem. – II[nd] - Examination – June/July- 2011

Subject code: 1722101

Subject Name: Design of Heat Exchange Equipments

Date:22/06/2011 **Time: 10:30 am – 01:00 pm**

Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** What is extended surface heat exchanger? Discuss plate-fin and tube-fin heat exchangers with their applications. **07**

(b) What is the heat capacity rate? What can you say about the temperature changes of the hot and cold fluids in heat exchangers if both fluids have the same capacity? What does a heat capacity of infinity for a fluid in a heat exchanger mean? **07**

Q.2 **(a)** Compare the LMTD and ε-NTU approach for analysis and design of heat exchangers. **07**

(b) Water at a flow rate of 5000 kg/h will be heated from 20 to 35°C by hot water at 140°C. A 15°C hot water temperature drop is allowed. A number of 1.5 m hairpins of 3 in (annulus inner diameter, D_i= 0.0779 m) by 2 in (inner tube d_o=0.0603 m and d_i = 0.0525 m) double pipe heat exchangers with annuli and pipes each connected in series will be used. Hot water flows through inner tube. Fouling factors are R_i = 0.000176 m^2-K/W and R_o = 0.000352 m^2-K/W. Assume that pipe is made of carbon steel (k = 54 W/m-K). Calculate the following **07**

Heat transfer coefficient for the fluid flowing through inner tube and annulus

The number of hairpins required

Use following properties date and correlation for calculation

Properties:

Inner tube	Annulus
ρ = 932.53 kg/m^3	ρ = 996.4 kg/m^3
C_p= 4.268 kJ/kg.K	C_p= 4.179kJ/kg.K
k = 0.687 W/m.K	k = 0.609 W/m.K
μ= 0.207 x 10^{-3} Pa.s	μ= 0.841 x 10^{-3} Pa.s
Pr = 1.28	Pr = 5.77

Dittus- Boelter correlation for both the fluids

$Nu_D = 0.023 Re_D^{0.8} Pr^n$ where n= 0.4 for heating and 0.3 for cooling

OR

(b) What is hairpin heat exchanger? Define hydraulic (D_h) and Equivalent (D_e) diameters for bare inner tube and annulus of a hairpin heat exchanger. **07**

Q.3 **(a)** What is a baffle? Discuss different type and geometry of baffles used in shell and tube heat exchangers. **07**

(b) In a shell and tube heat exchanger distilled water with a flow rate of 80,000 kg/h enters a shell side of the exchanger at 35°C and leaves at 25°C. Heat will be transferred to 1,40,000 kg/h of raw water coming from supply at 20°C. Calculate the length of the heat exchanger assuming following geometrical parameters. Consider the tubes are laid out on square pitch and material of tubes is carbon steel(k = 54W/m.K). **07**

Tube side specifications	Shell side specifications
O.D. = 0.0254 m	Pitch size = 0.03175 m
I.D. = 0.02291 m	Clearance = 0.00635 m
No. of tubes =81	Baffle spacing = 0.3048 m
No of pass = 1	Shell Dia. = 0.38735 m

Properties	Units	Tube side	Shell side
C_p	kJ/kg.K	4.179	4.1785
μ	Kg/m.s	0.00095	0.000797
k	W/m.K	0.6065	0.614
ρ	Kg/m^3	997	995.7
Pr		6.55	5.43
μ_w = 0.00086 Kg/m.s			

Use following correlations

Shell side

$$Nu = 0.36\left(\frac{D_e G_s}{\mu}\right)^{0.55}\left(\frac{C_p\mu}{k}\right)^{0.33}\left(\frac{\mu}{\mu_w}\right)^{0.14}$$

Tube side fluid

$Nu_D = 0.023Re_D^{0.8}Pr^n$ where n= 0.4 for heating and 0.3 for cooling

OR

Q.3 **(a)** Name and explain the various leakages and bypass streams taken in to account in determination of shell side heat transfer coefficient and pressure drop in Bell-Delaware method. **07**

(b) 1. What is impingement plate? How does it affect the number of tube count? **03**

2. Draw the four commonly used pitch lay-out patterns. **04**

Q.4 **(a)** Explain giving precious reason why fouling fluids are not used in compact heat exchangers **07**

(b) Explain rotary and fixed matrix regenerators with their applications. **07**

OR

Q.4 **(a)** Explain construction feature of Gasketed-Plate heat exchangers. **07**

(b) Air at 1 atm and 400 K and with a velocity of U_∞ =10 m/s flow across a compact heat exchanger matrix having 8.0-3/8 T geometrical configuration. Calculate the heat transfer coefficient, h, and frictional pressure drop for air side. The length of the matrix is 0.6m.Use following geometrical data and fluid properties. Refer Table 1 for j and f factors. **07**

Tube O.D. = 1.02 cm; fin pitch = 3.15/cm; fin thickness = 0.033 cm; fin area/total area = 0.839; air passage hydraulic diameter = 0.3633 cm; free-flow area/frontal area, σ=0.534;

Heat transfer area/total volume = 587 m^2/m^3

Properties of air at 400 K

P=0.8825 Kg/m^3; μ=2.29 x 10^{-5} Kg/m.s; C_p=1013 J/Kg.K; Pr=0.719

Table 1. j and f value for 8.0-3/8 T geometrical configuration

Re	j	f
2000	0.0080	0.027
2500	0.0075	0.026
3000	0.0070	0.025

Q.5	**(a)**	What are the different methods available in open literature for furnace design?	**07**
	(b)	What is the use of vent in a shell and tube condenser? Comment on the position of vent in horizontal and vertical axis shell and tube condenser.	**07**

OR

Q.5	**(a)**	Explain briefly about the type of evaporators used in refrigeration and air-conditioning systems.	**07**
	(b)	What is fouling? Explain types and mechanisms of fouling.	**07**

****